

Safe Use of Lasers

Los Alamos National Laboratory
Laboratory Implementation Guidance LIG 402-400-01.0
Issue Date: 5/21/99

Nonmandatory

1.0 Introduction

1.1 Background This is the companion Laboratory implementation guidance document that provides guidance for implementation of LIR 402-400-01, "Lasers."

1.2 In this Document

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2.0 Purpose

Provisions contained in this document are intended to provide guidance on implementation of the laser safety requirements.

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3.0 Definitions

3.1 The following acronyms and abbreviations are used in this document.

Acronyms

ANSI—American National Standards Institute

ES&H—environment, safety, and health

ESH—Environment, Safety, and Health Division

ESH-5—Industrial Hygiene and Safety Group

HCP—hazard control plan.

LSO—Laser Safety Officer

MPE—maximum permissible exposure

MSDS—material safety data sheet

SOP—safe/standard operating procedure (activity level)

3.2 Lasers are categorized according to ANSI Z136.1, which defines
Classification specific criteria for classifying lasers. The requirements for operating a laser are based on its classification.

Note: The following descriptions are generalizations and are not classification criteria.

class 1 laser—a laser or laser system that cannot emit hazardous laser radiation under normal operating conditions.

class 2 laser—a low-power, low-risk visible laser or laser system that does not normally present a hazard because of the eye's natural aversion response to bright light. However, directly viewing a class 2 laser for extended periods of time may result in eye damage.

class 3a laser—a medium-power laser or laser system that normally cannot produce a hazard if viewed for only momentary periods with the unaided eye. Class 3a lasers can present a more serious hazard if viewed through collecting optics, such as a microscope or telescope.

class 3b laser—a moderate-power laser or laser system that can produce an eye hazard from exposure to the direct beam or to specular reflection. Class 3b lasers also may present a minor skin hazard. Class 3b lasers do not produce hazardous diffuse reflections except at very close viewing distances.

class 4 laser—a high-power laser with a high risk of injury when the eye or skin is exposed to the direct beam or to specular or diffuse reflections. Class 4 lasers can also produce fire hazards because they have the ability to ignite combustible or flammable materials.

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3.3 Terms

continuous-wave (CW) laser—a laser operating with a continuous output for a period greater than or equal to 0.25 seconds.

diffuse reflection—reflection of a laser beam that is scattered in many directions by a surface or by a medium.

embedded laser—a laser with a classification higher than the inherent capability of the laser system in which it is incorporated, where the system's lower classification is appropriate because of engineering features that limit the accessible laser radiant output from the system.

Hazard Control Plan—a document that, at a minimum, defines the work, identifies the hazards associated with the work, and describes the controls needed to reduce the risk posed by the work to an acceptable level. (The hazard control plan may include detailed operating instructions.)

laser—a device that produces an intense, coherent, directional beam of visible or invisible light by stimulating electronic or molecular transitions to lower energy levels. Laser is an acronym for light amplification by stimulated emission of radiation.

laser controlled area—an area where the presence and activities of personnel are subject to control and supervision to protect them from the laser beam and its associated hazards.

laser personnel—persons who work directly with Class 3 or Class 4 lasers or laser systems.

laser safety officer (LSO)—one who has authority to monitor and enforce the control of laser hazards and effect the knowledgeable evaluation and control of laser hazards and provides support to line management.

laser system—an assembly of electronic, mechanical, and optical components that includes a laser.

maintenance—periodic routine adjustments or procedures that ensure continued, intended performance of a laser or laser system. Maintenance does not include operation or service.

maximum permissible exposure (MPE)—the level of laser radiation to which a person may be exposed without experiencing hazardous effects or adverse biological changes in the eye or skin. The MPE is determined by the criteria specified in Section 8 of ANSI Z136.1.

operation—performance of a laser or laser system over the full range of its normal, intended functions. Operation does not include maintenance or service.

service—procedures or adjustments that repair failures and restore a laser or laser system to its intended performance. Service does not include maintenance or operation

specular reflection—a mirror-like reflection.

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4.0 Hazard Evaluation

In the evaluation of laser hazards, the results should be documented on Form 1552, "Laser Registration and Hazard Evaluation Report," or equivalent.

Form 1552 is available online via the LANL Homepage, Information by Subject, Online Forms, ES&H Forms.

Form 1552 may also be used for embedded lasers that have been reclassified as class 1.

4.1 Hazard Control Plan/Safe Operating Procedures

The Hazard Control Plan/SOP for Class 3b and 4 Lasers, Form 2007, which may be used to create a safe operating procedure for laser operations, is included as Attachment 1. The HCP/SOP form consists of a series of blanks which when filled in will contain all the sections and information which should be included in a typical HCP/SOP for laser operations. As stated on the last page of the HCP/SOP form, a floor plan of the laser use area should be attached to the completed HCP/SOP form, which will serve to describe the laser set-up and controls. The completed HCP/SOP form should be submitted to the cognizant line manager and the LSO for approval.

5.0 Laboratory Standard Signs

5.1 Warning Signs

Standardized laser warning signs posted at entrances to areas and laboratories where class 3b or 4 lasers are operated, are available through laser safety suppliers or a LSO.

Laser Sign

Class 4 VISIBLE (DANGER)

Class 4 INVISIBLE (DANGER)

Class 3a and 3b VISIBLE (DANGER)

Class 3a and 3b INVISIBLE (DANGER)

Class 2 or 3a VISIBLE (CAUTION)

Class 2 or 3a INVISIBLE (CAUTION)

Note: Specific requirements for signs and posting can be found in ANSI Z136.1 section 4.3.15

The laser signs have blank areas below the laser sunburst where important laser information is to be written.

Note: If more than one class of laser is present, post only one sign. The other lasers, regardless of class, should be identified on that same sign in descending order of hazard.

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5.2 Access-Control Light Panels

The California-Avionics (CAL-AV) illuminated warning light panel, model WS-103A or LSO-approved equivalent, is a three-light unit that displays the status of the laser operation area and the entry precautions, as detailed in the table below (refer to Section 5.8 of LIR 402-400-01.1, "Lasers."). Access-control light panels are installed at entrances to class 3b and class 4 laser controlled areas. CAL-AV light panels, controllers, and bulbs can be ordered directly by calling the manufacturer at 1-520-624-1300.

Access-Control Light Panel			
Light	Warning	Meaning	Access
Red (Flashing)	DANGER No Entry	<ul style="list-style-type: none">class 4 laser in operation	<ul style="list-style-type: none">Entry not allowedDoor interlocks engaged
Yellow	CAUTION Controlled Entry Contact Operator	<ul style="list-style-type: none">class 3b laser in operation or power on for class 4 laserNo beam hazard at entry point	<ul style="list-style-type: none">Access controlledPermission required for entry
Green	SAFE Area Open	<ul style="list-style-type: none">No laser greater than class 3a in operationNo beam hazard at entry point	<ul style="list-style-type: none">Entry allowed

6.0 Recommended Laser Control Measures

Refer to Section 5.9 of LIR 402-400-01, "Lasers."

6.1 Class 1 Laser Controls

The following laser control measures are recommended for class 1 lasers.

- No special control measures are required during normal operation.
- Establish the laser operation area as a temporary controlled area during activation of an embedded class 3b or class 4 laser when the enclosure is opened for maintenance or service.

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6.2 Class 2 Laser Controls

The following laser control measures are recommended for class 2 lasers.

1. Enclose the laser in a protective laser housing—interlocked for class 3a (this should have been done by the laser manufacturer).
2. Attend a laser safety training course initially and every three years (call the ESH Training Center, 7-0059).
3. Ensure that the appropriate warning label is on the laser and is clearly visible.
4. Control the laser beam by
 - ensuring that the beam is not at eye level,
 - minimizing specular reflections, and
 - terminating the beam at the end of its useful path.
5. Do not allow personnel to stare into the laser beam.
6. Do not allow personnel to view the laser beam with collecting optics that can produce eye exposures greater than the MPE (maximum permissible exposure).
7. Establish the laser operation area as a temporary laser controlled area during activation of an embedded class 3b or class 4 laser when the enclosure is opened for maintenance or service.

6.3 Class 3b and Class 4 Laser Controls

The following laser hazard control measures are recommended for class 3b lasers.

Requirements Note: Control measures are required for class 4 lasers as stated in ANSI Z136.1

The use of these control measures will help protect personnel from harm.

1. Enclose the laser in an interlocked protective enclosure (if not already done by the laser manufacturer).
2. Consider fully enclosing the laser **system** in an interlocked enclosure, when appropriate and possible, to achieve class 1 laser status.
3. Establish a class 3b or class 4 laser controlled area, as appropriate, for the laser system in use.
4. Design area and entryway controls for both rapid egress by laser personnel at all times and prompt admittance to area under emergency conditions.
5. Install a clearly marked “Panic Button” for reducing the laser’s output to the applicable MPE under emergency conditions in class 4 laser operations.

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6.3 Class 3b and Class 4 Laser Controls (continued)

6. Ensure that laser personnel receive a base-line laser eye examination as soon as possible after their assignment.
7. Ensure that only competent and authorized personnel operate the laser system.
8. Provide a key-operated or coded-access master switch for class 4 lasers and consider such a switch for class 3b lasers; disable the master switch when the laser or laser system is not intended for use.
9. Attend a laser safety training course initially and every three years (call the ESH Training Center).
10. Write, process, post, and use an LSO-approved SOP or HCP for all class 3b and class 4 lasers except CW (continuous-wave) lasers with an output less than 50 milliwatts between 400 nanometers and 750 nanometers.
11. Ensure that a "Danger" label is on the laser and is clearly visible.
12. Post a "Danger Laser" sign at all entrances to the laser operation area.
13. Control access to laser operation areas and give safety orientation to all visitors and spectators.
14. Install the standard three-light access-control panel at entrances to the laser operation area for access control.
15. If there is a potential beam hazard at the doorway, interlock the access doors for class 4 laser operations and consider interlocking doors for class 3b operations.
16. Check, verify, and document quarterly that interlocks are functioning properly.
17. Write an SOP or HCP that defines the conditions of coexistence and methods of safe operation for multiple separate laser operations in a single area.
18. Give an audible or visual warning before laser activation or start-up that allows personnel sufficient time to avoid exposure.
19. When appropriate and possible, operate class 4 laser systems remotely and use an appropriate warning before activating the system.
20. Use alternative control measures approved by the cognizant LSO to prevent exposures greater than the appropriate MPE whenever the protective housing is opened or removed, by
 - mounting the laser system securely on a stable platform;
 - enclosing the beam to the maximum practical extent (full enclosure with interlocked access desirable);

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6.3 Class 3b and Class 4 Laser Controls (continued)

- using a permanently attached beam stop or attenuator to reduce the laser radiation level to the appropriate MPE when laser output is not required;
- using a temporary beam attenuator during maintenance, service, or alignment to reduce accessible radiation to class 1 or class 2 levels;
- allowing no accessible unenclosed beam at eye level (nominally 4.5–6 feet above floor level, but it may extend lower if workers are seated in the vicinity of laser operations);
- minimizing all reflections (specular and diffuse) for class 4 lasers and specular reflections for class 3b lasers;
- terminating the beam at the end of its useful path (fire-resistant beam stop for class 4 cw lasers);
- interlocking the critical beam stops that prevent beams from leaving the horizontal optical plane or entering aisles, entryways, or other areas that might be populated;
- enclosing or shielding all beams that depart from the horizontal optical plane;
- incorporating suitable means (such as interlocks, filters, or attenuators) in all viewing portals, display screens, and collecting optics to maintain laser radiation at less than the applicable MPE at the viewing position;
- making sure that the beam is directed away from access doors and populated areas;
- making sure that no laser radiation hazard is present at the point of entry into the laser operation area;
- confining the laser beam to the optical table and to the protected and clearly identified beam paths (e.g., using beam fences, tubes, etc.);
- designing and specifying alignment procedures in the HCP or SOP to be used to keep exposure as low as practical;
- allowing no unenclosed beams greater than the MPE to exit the laser operation area;
- replacing specularly reflective surfaces with diffuse reflective materials
- enclosing or shielding specularly reflective optics needed for beam control; and

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6.3 Class 3b and Class 4 Laser Controls (continued)

- locating, identifying, and controlling all hazardous direct, and reflected beams, and any residual leakage using appropriate viewers, detectors, etc.
- 21. Fiber optics systems should be controlled and labeled in accordance with ANSI Z 136.1, Section 4.5.2.
- 22. Do not look directly into the laser beam.
- 23. Wear protective eyewear when other controls do not reduce potential eye exposure to nonhazardous levels.
- 24. Wear protective clothing when other controls do not reduce potential skin exposure to less than the skin MPE.
- 25. Evaluate and control associated hazards (such as electrical, carcinogenic, toxic, pressure, cryogenic, and ionizing radiation) in accordance with the appropriate ES&H policies & procedures and other applicable standards and regulations.

7.0 References

7.1 Documents

“American National Standard for the Safe Use of Lasers,” ANSI Z136.1 (American National Standards Institute, 1993).
LANL LIR402-400-01 “Lasers”
Laser Safety Committee Charter
LIR 300-00-01.0, “Safe Work Practices”
LIR402-100-01 “Signs, Labels, and Tags”
LS107-03 X-Ray Generating Devices
LP106-01.2 Lockout/Tagout for Control of Hazardous Energy

7.2 Referrals

Industrial Hygiene and Safety Group (ESH-5, Operational Safety Section)
Occupational Medicine-Nurses Station (ESH-2)
Emergency Management Office (EMO)
ES&H Training Group (ESH-13)
JIT/Customer Service/Small Purchase Group (BUS-6)

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7.3 Document Ownership

The Office of Institutional Coordination for this document is ESH-5.

8.0 Attachment

Attachment 1: Hazard Control Plan/SOP for Class 3b and 4 Lasers,
Form 2007

Hazard Control Plan/SOP for Class 3b and 4 Lasers

Title:
HCP (formerly SOP) Number:
Overall Initial risk estimate:
Name(s) of the reviewer(s) consulted on the hazard control system. Requirements Note: This is required for medium initial-risk activities.
Name, title, and signature(s) of the reviewer(s) to indicate concurrence with the hazard control system. Requirements Note: This is required for high initial-risk activities; Laser Safety Officer signature required by ANSI Z136.1 for Class 4 lasers):
Identification of work permits required for the tasks described:
Overall Residual risk estimate:
Name and contact information of the (principal) author (<i>Name/MS/ Phone /Fax/ E-mail</i>):
Next authorization review date:
Name, title, and signature of authorizer (<i>line manager</i>):
Effective authorization date (<i>date signed by authorizer</i>):

Note: The hazard control plan may be a combination of documents, which contain the essential information, or may reference other documents, without reproducing them. When other documents are referenced, the source or method of access for the documents must be specified.

Note: For work involving hazards such as confined spaces; energized electrical exposure; excavation or fill; ionizing radiation; welding, cutting, or other spark/flame-production; special review and documentation with the appropriate work permit is required. Additional permits, sometimes from other agencies, may also be required for special classes of work such as hazardous materials shipment or certain types of fieldwork. For more information contact an ES&H subject matter expert or the Facility Manager.

Hazard Control Plan for Class 3b and 4 Lasers (cont.)

Fill in the requested information below.

- 1.0 Description of the Work** *(include sufficient detail to readily understand the context, for example, materials, equipment, interfaces, and locations of the hazards and the controls established):*
- 2.0 Location of Work** *(TA-building-room or describe other location):*
- 3.0 Duration of activity/application:**
Indefinite _____, limited period _____ months
- 4.0 Identification of Hazards** *(based on a systematic evaluation of the circumstances in which these hazards could cause harm in the context of the work being performed; include laser beam and non-beam hazards):*

4.1 Laser Hazards		<u>Laser 1</u>	<u>Laser 2</u>	<u>Laser 3</u>
Type of Laser:				
Class:				
Property # (PN)				
Wavelength Used				
CW	Power (W) <i>(typical used)</i>			
P	Pulse Length (s)			
P	Energy/Pulse (J) <i>(typical)</i>			
P	Rep. Rate (Hz)			

CW= Continuous wave laser; P = Pulsed laser

4.2 Non-Beam Hazards Mark an "x" for all that apply:	<u>Specify Hazard Controls</u> (attach additional page if needed)
() Electrical (<50 V)	
() Electrical (>50 V)	
() Ionizing Radiation	
() Non-Ionizing Radiation	
() Non-Flammable Gas	
() Flammable Gas	
() Flammable Liquid	
() Toxic Chemicals	
() Biological Agents	
() Carcinogens	
() Category I Chemicals	
() Fire	
() Explosives	

Hazard Control Plan for Class 3b and 4 Lasers (cont.)

4.2 Non-Beam Hazards Mark an "x" for all that apply:	<u>Specify Hazard Controls</u> (attach additional page if needed)
() Pyrophoric material	
() Thermal Energy	
() Cryogenics	
() Pressures > 15psia	
() Mechanical	
() Exposed Energy	
() Limited Egress	
() Confined Space	
() High Vacuum	
() Other hazards, explain	

5.0 Discussion of Initial Risk (*per LIR300-00-01 risk matrix; posed by these hazards and circumstances in which these hazards could cause harm in the context of the work being performed*):

6.0 Description of Controls (*elimination, substitution, engineering controls, administrative controls, and/or personal protective equipment that were developed or modified to achieve acceptable risk and that compose the hazard control system*)

6.1 Describe Laser Hazard Controls (*Explain how laser hazard is controlled when the room is on: red light condition, and yellow light condition*):

6.2 Describe Laser Alignment Procedures (e.g., room on red light condition, lowest possible power, use of fluorescent cards or viewing scope, only essential personnel wearing laser protective eye wear in the area, block laser beams when lenses or mirrors are added or removed, personnel shall avoid bending over the optical table, errant beams shall be intercepted on the optical table, direct exposure to the beam or its reflections shall be avoided, etc.):

6.3 Attach A Floor Plan of Laser Use Area (*a simple drawing will do, may also be posted on laboratory door. Include on the floor plan: the walls, doors, windows, laser table(s), barriers, signs, etc.*).

6.4 Describe Non-Beam Hazard Controls:

7.0 Discussion of Residual Risk

8.0 List Institutional, Facility, or Operational Specific Requirements Documents (*that are directly related to the defined work, for example, LIR402-400-01, "Lasers," for laser activities*):

9.0 Task/Training Matrix (*list the task(s), describe the knowledge, skills, and abilities necessary to use the controls and to perform the task safely, list the training, both formal and on-the-job, necessary to obtain the requisite knowledge and skills*):

Hazard Control Plan for Class 3b and 4 Lasers (cont.)

10.0 Description of Wastes or Residual Materials *(produced, if any, and how handled):*

11.0 Description of Emergency Actions *(to be taken in the event of control failure or abnormal operation):*

12.0 Reference the Change Control Process *(may reference an organizational procedure that controls the preparation and review of HCPs):*

13.0 List of Authorized Workers *(suggestion-include tasks to which each is assigned; include as an attachment):*

Note: As required by LIR402-400-01, a completed and approved Laser Registration and Hazard Evaluation Report(s) (Form 1552 or equivalent as determined by an LSO) must be attached to this HCP/SOP for all Class 3b and 4 lasers.